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CRWMS/M&O

Calculation Cover Sheet

Complete only applicable items.

1. QA: L

Page: 1 Of: 15

2. Calculation Title Total System Performance Assessment - License Application Design Selection (LADS) Phase 1 Analysis for Higher Thermal Load (Feature 26)			
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	Print Name	Signature	Date
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10. Remarks

Editorial changes have been made including:

- Font and alignment of figure captions changed
- Content section expanded to include 3 heading levels
- "NV" changed to "Nevada" in reference citations
- Period added after first level heading numbers

NE 6/23/99

-Changed "MGDS" to "MGR" on title page NE 6/29/99

V.P. 6/29/99 V.P. 6/23/99

Revision History

11. Revision No.	12. Date Approved	13. Description of Revision
00	6/11/99	Initial Issue

Title: **Total System Performance Assessment - License Application Design Selection (LADS) Phase 1 Analysis for Higher Thermal Load (Feature 26)**

Document Identifier: **B00000000-01717-0210-00068 REV 00**

Originator: **Nelson Erb**

Checker: **Mike Gross**

Lead Design Engineer: **Vinod Vallikat**

Date: **11 June 1999**

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1. Purpose

The objective of this report is to evaluate the effect of potential changes to the TSPA-VA base case design on long-term repository performance. The design feature that is evaluated in this report is a higher thermal load (Feature 26 or F26). The following paragraph briefly describes the motivation for evaluating higher thermal loading.

Higher thermal load has been identified as a design feature that might have a beneficial effect on long-term repository performance. A higher thermal load will increase temperatures and decrease relative humidity on the waste package surface. The decrease in relative humidity may delay the onset of corrosion, thus delaying the failure of waste packages and the release of radionuclides from the engineered barrier system (EBS). For the current calculation a thermal load of 109 MTU/acre (metric tons of uranium per acre) is considered. Two cases are evaluated, one with the base case inventory and a higher thermal load and a second with an increased inventory that would cover the current repository footprint at the higher thermal load.

This report documents the modeling assumptions and calculations conducted to evaluate the long-term performance of higher thermal loading. The performance measure for this evaluation is dose-rate. Results are presented that compare the dose-rate time histories with the new design feature to that for the TSPA-VA base case calculation (CRWMS M&O, 1998a).

2. Method

Total system performance assessment calculations require coupling and/or information transfer between models that represent the major components of the repository. These models, their coupling, and input parameter values used in the TSPA-VA base case are described in *Total System Performance Assessment – Viability Assessment Base Case* (CRWMS M&O, 1998a). The overall computational system remains unchanged for the higher thermal load assessments presented in this report. However, the implementation of various components of the model is changed to account for the effects of the design feature. The changes to the base case model are described in the following assumptions and calculation sections of this document.

3. Assumptions

The assumptions for the RIP analyses for higher thermal load are described in this section. Assumptions listed in the base case calculation document (CRWMS M&O, 1998a) are also applicable.

- Only the thermal environment is changed for F26. Repository regions and hydrologic response remain unchanged
  The shapes and sizes of the repository regions remain unchanged for these calculations. The

hydrologic environment in the repository is also unchanged for these calculations. At the time the calculation was performed, no information about the effect of higher thermal loading on dripping flux and other hydrologic parameters was available. For the purpose of these LADS Phase I calculations it is sufficient to assume that base case conditions can be used as an appropriate approximation. Used in Sections 5.3, 5.4, 5.5.1 and 5.5.2.

- Two cases are evaluated, one with the base case inventory and another with an expanded inventory. The repository for both cases is assumed to have the same footprint as the base case repository.
  Even though a repository with a higher thermal load and the base case inventory would have a smaller footprint than the base case repository, for the purpose of modeling the base case footprint is used for both increased and base case inventory calculations. This simplifying assumption is a sufficient approximation for the current LADS Phase 1 calculations. Used throughout Section 5.
- The increased package temperature associated with higher thermal loading causes cladding degradation from increased creep strain.
  The delay in emplacing backfill keeps most cladding below 350 °C to enhance cladding performance (CRWMS 1998e, p. 8-1). Used in Section 5.5.
- Packages with juvenile failures do not experience increased cladding degradation.
  Only a small fraction (13.9%, see section 5.5) of the packages experience increased cladding failure so it is assumed that the juvenile failure packages are not in that fraction. Used in Section 5.5.
- The assumptions made about waste package degradation are discussed in CRWMS M&O 1999, Item 2, page 5.
  Used in Section 5.3.
- The assumptions made about thermal hydrology are discussed in CRWMS M&O 1999, Item 1, page 8.
  Used in Section 5.2.

4. Use of Computer Software

4.1 Software Approved for QA Work

The software used for modeling different components of the repository system in the TSPA-VA total system model are listed in this section. The FEHM software (TBV 564) has not been verified at the time of the calculations and the results from these calculations should be considered TBV (to be verified). The software used for the analyses presented in this document include the same software used for the TSPA-VA base case calculation (CRWMS M&O, 1998a). No new software was used for the design feature analyses.

WAPDEG and NUFT are used to produce waste package degradation and thermal hydrology inputs to the total system model. These two programs are mentioned in the calculation section of this document but are not described here. This is appropriate because the use of this software is described in a separate document (CRWMS M&O, 1999, Item 1 and Item 2).

4.1.1 RIP Version 5.19.01, CSCI: 30055

Installed on a dual processor Intel Pentium II-based IBM compatible personal computer under the Windows NT 4.0 Operating system.

Since RIP is used as the integrating shell for combining the different components of the repository system, all the input/output files required for running the TSPA-VA base case model are provided in DTN: MO9807MWDRIP00.000 and are discussed in CRWMS M&O, 1998a. Files that were changed or added for individual analyses are listed in Attachment I in directories that correspond to the particular simulation. These files are provided in the DTN MO9904MWDRIP68.001.

a) The RIP computer code (Golder Associates, 1998) is an appropriate tool to perform the following functions that are part of the Total System Performance Assessment: (1) Simulate the release of radionuclides from the engineered barrier system, including the effects of radioactive decay, package failure, dissolution of radionuclides and transport through the engineered barrier system. (2) Simulate the impact of radionuclides on the biosphere, including the determination of exposure to identified populations.
b) This software has been validated over the range it was used. (*Software Qualification Report, Repository Integration Program*, Version 5.19.01, DI: 30047-2003, Rev. 2, CRWMS M&O, 1998b)
c) This software was obtained from Software Configuration Management (SCM) in accordance with the appropriate procedures.

4.1.2 FEHM Version 2.0.0 , CSCI: N/A (TBV 564)

FEHM Version 2.0.0 was compiled as a dynamic link library (DLL) with Digital Visual Fortran 5.0 and is used as an external subroutine (fehmn.dll) to RIP 5.19.01. This DLL was installed on a dual processor Intel Pentium II-based IBM compatible personal computer under the Windows NT 4.0 operating system. Files from the TSPA-VA base case are provided in DTN MO9807MWDRIP00.000 and are described in CRWMS M&O, 1998a. Any files that were changed are listed in Attachment I and are provided in DTN MO9904MWDRIP68.001.

a) The FEHM computer code is an appropriate tool to perform mass transport simulations in the saturated and unsaturated zones below the potential Yucca Mountain repository (Zyvoloski et al., 1997).
b) This software has not been validated over the range it was used.

c) This software was not obtained from SCM in accordance with the appropriate procedures.

4.2 Software Routines

4.2.1 SZ_Convolute, Version 1.0, CSCI: 30038

SZ_Convolute was compiled as a dynamic link library using Digital Visual Fortran 5.0 and is used as an external subroutine (szconv.dll) to RIP. This DLL was installed on a dual processor Intel Pentium II-based IBM compatible personal computer under the Windows NT 4.0 operating system.

The program is written in the FORTRAN programming language and uses a convolution integral technique to combine concentration breakthrough curves based on unit releases with transient radionuclide mass flux at the water table to determine radionuclide concentrations at a specified downstream boundary for which the concentration breakthrough curves were derived. The underlying assumptions in using convolution are: (1) the transport processes and flow fields from the unsaturated zone model and the saturated zone model are independent of one another, (2) the transport processes in the saturated zone model are linear, and (3) steady-state flow is valid for the saturated zone. More information on the formulation and inputs can be found in *Software Routine Report for SZ_Convolute* (CRWMS M&O, 1998c).

4.2.2 TRANSP Version 1.0, CSCI: 30065

External Functions for the Dissolution Rate and Diffusion Coefficient Calculations within RIP (TRANSP) (CRWMS M&O, 1998d), contains three DLLs (dynamically linked libraries).

SFDiss, GLDiss, and EDCoef were compiled as dynamic link libraries using Visual C++ 4.0 to be used as external subroutines (sfdis.dll, gldiss.dll, and edc.dll) to RIP. These DLL's were installed on a dual processor Intel Pentium II-based IBM compatible personal computer under the Windows NT 4.0 operating system.

SFDiss is a subroutine written in C programming language to calculate the commercial spent fuel dissolution rate based on the equation developed from experimental data. More details on the formulas used and inputs for this subroutine can be found in Software Routine Report, *External Functions for Dissolution Rate and Diffusion Coefficient Calculations within RIP for TSPA-VA* (CRWMS M&O, 1998d).

GLDiss is a subroutine written in C programming language to calculate the glass dissolution rate based on the equation developed from experimental data. More details on the formulas used and inputs for this subroutine can be found in Software Routine Report, *External Functions for*

Dissolution Rate and Diffusion Coefficient Calculations within RIP for TSPA-VA (CRWMS M&O, 1998d).

EDCoef is a subroutine written in C programming language to calculate the effective diffusion coefficient in an unsaturated porous medium based on the equation developed from experimental data. More details on the formulas used and inputs for this subroutine can be found in Software Routine Report, *External Functions for Dissolution Rate and Diffusion Coefficient Calculations within RIP for TSPA-VA* (CRWMS M&O, 1998d).

5. Calculation

The TSPA-VA base case model and parameters were used with only minor changes to the RIP input files to account for the effects of the design feature. The base case model and parameters are presented in the *Total System Performance Assessment-Viability Assessment Base Case Revision 01* (CRWMS M&O, 1998a). Components of the base case calculation that were not changed for the design feature analyses are not discussed in this document.

The input/output files for these calculations are based on unqualified data. Most parameters used in the TSPA-VA base case calculation are non-qualified (NQ). For the exact Q-status of individual base case parameters see CRWMS M&O 1998a.

5.1 Conceptual Model

The base case model remains essentially the same with only a few minor changes to account for the increased thermal load. The increased thermal load causes an increase in cladding degradation due to an increase in waste package temperature. The fraction of packages that experience the increased cladding failure are all placed in region 3 of the repository. Also, the temperature histories and waste package failure histories are changed to account for the higher thermal load.

5.2 Thermal Hydrology

There is a change in drift scale thermal hydrology results due to the increase in thermal loading over the base case. New drift-scale thermal hydrology histories for the higher thermal load were generated using the finite-difference computer program NUFT (CRWMS M&0, 1999; DTN LL981109204242.066). The temperature histories are used for waste form dissolution calculations. The NUFT calculations generate temperature and relative humidity time histories at the waste package surface for the northeast region of the repository. These histories are then input to WAPDEG v. 3.09 for predictions of long-term waste package degradation.

Average waste package temperature histories for each repository region are also required as a direct input to RIP from NUFT (DTN LL981109204242.066). The base case temperature files for Commercial Spent Nuclear Fuel (CSNF) and Defense High Level Waste (DHLW) packages calculated with expected value infiltration parameters are replaced with files containing the new thermal histories from NUFT for a repository with a higher thermal load. This information is passed to RIP in input files *.t02 and *.t05 for CSNF and DHLW, respectively. The other temperature input files for RIP are not used for expected value simulations and therefore did not need to be replaced. Thermal hydrology data provided for this calculation are NQ.

5.3 Waste Package Degradation

New waste package degradation histories were generated for the higher thermal load design feature to account for the changes in temperature and relative humidity associated with the higher thermal load. WAPDEG v. 3.09 was used to generate the waste package failure histories along with the average number of patches and pits per failed waste package (DTN MO9903MWDHTL62.000). The temperature and relative humidity data is generated by NUFT (see section 5.2). Waste package degradation is based on the assumptions described in CRWMS M&O 1999, Item 2, page 5.

The base case expected value waste package failure and patch/pit history files for dripping and non-dripping packages (tables *.t20 and *.t35) are replaced with new histories for the higher thermal load design feature with expected value conditions.

Waste package degradation data provided for this calculation are NQ.

5.4 Inventory

Two cases are evaluated for the current calculation: (1) a calculation with the TSPA-VA base case inventory at the higher thermal load and (2) a calculation with an increased inventory at the higher thermal load. For the base case inventory calculation, the same number of waste packages are used as were used in the TSPA-VA base case calculation. The inventory for the other calculation was increased by a factor of 109/85 (109 MTU/acre vs. 85 MTU/acre used in the TSPA-VA base case). With this increase in inventory, the same amount of area is used as is used in the base case calculation. The following table shows the number of commercial spent nuclear fuel (CSNF), high level waste (HLW) and Dept. of Energy spent fuel (DOESF) waste packages used for the increased inventory:

	Base Case Packages	Calculation	Increased Inventory Packages
CSNF	7760	7760*109/85	9951
HLW	1663	1163*109/85	2133
DOESF	2546	2546*109/85	3265

5.5 Cladding Degradation

Associated with the higher thermal load is an increase in waste package and cladding temperature. Within some of the CSNF packages, the cladding temperature exceeds 350 degrees Celsius. Cladding failure due to creep failure of pins increases with the increased cladding temperature. For the higher thermal load about 13.9% of packages experience some increase in cladding failure due to creep (DTN: MO9904SPACLD39.000, feature26.xls, cells H8+H9 (bins 1 and 2). The insignificant amount of cladding failure associated with bin 12 is ignored for this calculation). Within the packages that experience some increased cladding failure, 31.92% of the pins fails due to creep (DTN MO9904SPACLD39.000, feature26.xls, cells K8 and K9). The packages with increased cladding failure are given an initial failure rate of 33.17% (31.92% + 1.25% from stainless steel and other juvenile failures). The cladding failure for all other packages remains the same as the base case.

Within RIP, all of the packages with increased cladding failure are assigned to region 3 of the repository. It is conservative to assume that all of the packages with increased cladding are in region 3 because this region has the greatest dripping flux, and therefore the greatest potential for the advective releases from the waste packages. The other waste packages are divided between the remaining 5 regions based on the proportional area of these regions. Sections 5.5.1 and 5.5.2 describe the calculation for the number of packages in each repository region.

The cladding degradation data provided for this calculation are NQ.

5.5.1 Base Case Inventory at Higher Thermal Load

For the base case inventory calculation at the higher thermal load there are a total of 7760 CSNF packages. 1079 of the packages (13.9%) have increased cladding failure and are placed in region 3. The other 6681 packages are divided between the other 5 repository regions:

	Fractional Area (less region 3)*	Calculation	Final Packages
Region 1	1033/5438	6681*1033/5438	1269
Region 2	1220/5438	6681*1220/5438	1499
Region 3	N/A	N/A	1079
Region 4	754/5438	6681*754/5438	926
Region 5	537/5438	6681*537/5438	660
Region 6	1894/5438	6681*1894/5438	2327**

*fractions based on the number of CSNF packages in each region for the base case
**minus the juvenile failure packages

The juvenile failure packages are taken from region 6 because region 6 is the largest region and will be least affected by the removal of the juvenile failure packages. As with the base case, however, the juvenile packages experience the dripping flux of region 3. This is conservative since region 3 has the greatest dripping flux. The parameter NUMCSF has been altered to implement the change in the juvenile package. NUMCSF is given as the number of packages in region 6 and is equal to "2327 – JFFRAC" (the number of packages in region 6 minus the number of juvenile failure packages).

5.5.2 Increased Inventory at Higher Thermal Load

For the increased inventory at the higher thermal load there are a total of 9951 CSNF packages. 1383 of the packages (13.9%) have increased cladding failure and are placed in region 3. The other 8568 packages are divided between the other 5 repository regions:

	Fractional Area less region 3*	Calculation	Final Packages
Region 1	1033/5438	8568*1033/5438	1628
Region 2	1220/5438	8568*1220/5438	1922
Region 3	N/A	N/A	1383
Region 4	754/5438	8568*754/5438	1188
Region 5	537/5438	8568*537/5438	846
Region 6	1894/5438	8568*1894/5438	2984**

*fractions based on the number of CSNF packages in each region for the base case
**minus the juvenile failure packages

The juvenile failure packages are taken from region 6 because region 6 is largest region and will be least affected by the removal of the juvenile failure packages. As with the base case, however, the juvenile packages experiences the dripping flux of region 3. This is conservative since region 3 has the greatest dripping flux. The parameter NUMCSF has been altered to implement the change in the juvenile package. NUMCSF is given as the number of packages in region 6 and is equal to "2984 – JFFRAC" (the number of packages in region 6 minus the number of juvenile failure packages).

For the increased inventory case, the number of HLW and DOESF waste packages are increased in each region by a factor of 109/85 to represent the increase in areal mass loading.

5.6 Summary of Changes to RIP

- Increased number of CSNF, HLW and DOESF packages for increased inventory calculation
- replaced tables *.t02 and *.t05 for new expected value thermal histories
- replaced tables *.t20 and *.t35 for new expected value WAPDEG results for dripping and non-dripping packages
- CSNF packages with increased cladding failure are placed in region 3

- Other CSNF packages are proportionally redistributed to Regions 1,2,4,5 and 6
- Parameter NUMCSF is changed to "2327-JFFRAC" for base case inventory and "2984-JFFRAC" for increased inventory case

6. Results

Since unqualified inputs were used in the development of the results presented in this section, they should be considered TBV. This document will not directly support any construction, fabrication, or procurement activity, and therefore, the inputs and outputs are not required to be procedurally controlled as TBV. However, any use of the data from this analysis for inputs into documents supporting construction, fabrication, or procurement is required to be controlled as TBV in accordance with appropriate procedures.

The following table summarizes several post-closure performance measures. These performance measures are useful for providing objective measures of the performance-related benefit of a LADS feature in comparison to the base case. The suggested post-closure performance measures are as follows:

- The peak dose rate and its time of occurrence during the first 10,000 years after closure. This is a reasonable criterion because 10,000 years is the likely regulatory period.

- The peak dose rate and its time of occurrence during 1,000,000 years. Periods up to 1,000,000 years may be considered during licensing. Note that the peak dose rate often occurs during the first or second superpluvial (SP) period, around 300,000 or 700,000 years.

- A figure of merit (FOM) based on the weighted dose rate over the time period of interest. The FOM is defined as:

$$FOM = \frac{1}{\ln[1x10^6] - \ln[1x10^3]} * \int_0^T \frac{r}{t} dt,$$

where
r is the dose rate (mrem/year),
t is the time (years), and
T is the period of interest (years).

Note that this FOM has the units of mrem/year and that the time variable is inside the integral sign, which has the effect of weighting early-time doses more than late-time doses. Results for the simple FOM calculation are found in "f26_da3_fom.xls" in DTN MO9904MWDRIP68.001.

Feature	Description	FOM	10,000-Year Duration Peak Rate (mrem/yr)	10,000-Year Duration Time (years)	1,000,000-Year Duration Peak Rate (mrem/yr)	1,000,000-Year Duration Time (years)
Base case	Base Case	25.02	0.04218	10000	300.9	317000
F26	High Thermal Load (109 MTU/acre), base case inventory	34.70	0.2344	10000	344.3	317000
F26	High Thermal Load (109 MTU/acre), increased inventory	44.66	0.3190	10000	450.2	317000

The dose-rate histories for the higher thermal load cases are provided in Figures 1 and 2. For the first 6,000 years, dose rates for the base case and higher thermal load cases are nearly identical since the impact of the juvenile failure package is similar for all of these cases (Figure 1). After 6,000 years, the dose rates for the higher thermal load cases are greater than for the base case (Figures 1 and 2). The increase in dose rate is attributed to the increase in cladding failure from the higher cladding temperatures associated with the increased thermal load.

7. References

CRWMS M&O 1998a. *Total System Performance Assessment – Viability Assessment Base Case.* B00000000-01717-0210-00011 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981202.0279.

CRWMS M&O 1998b. *Software Qualification Report, Repository Integration Program (RIP), Version 5.19.01.* Software Configuration Identifier (CSCI): 30055 V.5.19.01. DI: 30047-2003 REV 2. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980916.0337.

CRWMS M&O 1998c. *Software Routine Report for SZ_Convolute.* Version 1.0 DI: 30038-2999 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981103.0084.

CRWMS M&O 1998d. *Software Routine Report, External Functions for Dissolution Rate and Diffusion Coefficient Calculations within RIP for TSPA-VA.* Version 1.0 DI: 30065-2999 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19981120.0103.

CRWMS M&O 1998e. *Controlled Design Assumptions Document.* B00000000-01717-4600-00032 REV 05. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980804.0481.

CRWMS M&O 1999. *Design Input Transmittal for NUFT (Thermal Hydrology) and WAPDEG output for DF26 (Higher Thermal Load).* Input Tracking No. SSR-PA-99058.T. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.199990301.0237.

Golder Associates 1998. *RIP Integrated Probabilistic Simulator for Environmental Systems: Theory Manual and User's Guide.* Redmond, Washington: Golder Associates Inc. TIC: 238560.

Zyvoloski, G.A.; Robinson, B.A.; Dash, Z.V.; and Trease, L.L. 1997. *Summary of the Models and Methods for the FEHM Application - A Finite-Element Heat- and Mass- Transfer Code.* LA-13307-MS. Los Alamos, New Mexico: Los Alamos National Laboratory. TIC: 235587.

8. Attachments

I. Directories of Input/Output Files (6 pages)

II. Result Figures (3 pages)

Attachment I

Directories of Input/Output Files

For Detail and Explanation of Directories and Files, See readme.txt in DTN: MO9904MWDRIP68.001

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04/06/99  10:08p            12,865 readme.txt
              7 File(s)      1,040 bytes

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12/30/98  03:00p            88,192 F26AE4.BPF
12/30/98  03:00p            12,008 F26AE4.bsr
12/30/98  02:53p           583,384 F26AE4.BTF
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12/23/98  01:52p            11,107 f26ae4.t05
04/04/98  11:44p            11,715 f26ae4.t06
03/28/98  07:25a             6,070 f26ae4.t07
03/27/98  09:33a             6,002 f26ae4.t08
03/28/98  07:30a             6,002 f26ae4.t09
03/27/98  09:33a             6,002 f26ae4.t10
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03/30/98  02:30p           1,990 f26ae4.t36
04/01/98  06:57a           1,865 f26ae4.t37
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 Directory of G:\f26ae6

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12/23/98  04:35p          12,008 F26AE6.bsr
12/23/98  02:04p         585,184 F26AE6.BTF
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04/04/98  11:43p          11,979 f26ae6.t01
12/23/98  01:52p          11,250 f26ae6.t02
04/04/98  11:44p          11,964 f26ae6.t03
04/04/98  11:44p          12,266 f26ae6.t04
12/23/98  01:52p          11,107 f26ae6.t05
04/04/98  11:44p          11,715 f26ae6.t06
03/28/98  07:25a           6,070 f26ae6.t07
03/27/98  09:33a           6,002 f26ae6.t08
03/28/98  07:30a           6,002 f26ae6.t09
03/27/98  09:33a           6,002 f26ae6.t10
03/27/98  09:34a           6,070 f26ae6.t11
03/27/98  09:34a           6,070 f26ae6.t12
03/27/98  09:35a           6,070 f26ae6.t13
03/27/98  09:35a           6,070 f26ae6.t14
03/27/98  09:35a           6,070 f26ae6.t15
03/27/98  08:27a           6,070 f26ae6.t16
03/27/98  08:27a           6,002 f26ae6.t17
03/27/98  08:28a           6,002 f26ae6.t18
03/27/98  08:34a           6,002 f26ae6.t19
12/14/98  12:21p           6,311 f26ae6.t20
03/27/98  08:35a           6,002 f26ae6.t21
03/27/98  08:36a           6,070 f26ae6.t22
03/27/98  08:41a           6,070 f26ae6.t23
```

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03/27/98  08:41a          6,070 f26ae6.t24
03/27/98  09:41a          6,002 f26ae6.t25
03/27/98  09:41a          6,070 f26ae6.t26
03/27/98  09:41a            698 f26ae6.t27
03/27/98  09:41a          6,002 f26ae6.t28
03/27/98  09:42a          6,002 f26ae6.t29
03/27/98  09:42a          6,070 f26ae6.t30
03/27/98  09:42a          6,070 f26ae6.t31
03/27/98  09:43a          6,070 f26ae6.t32
03/27/98  09:43a          6,070 f26ae6.t33
03/30/98  02:38p          2,874 f26ae6.t34
12/14/98  12:21p          2,911 f26ae6.t35
03/30/98  02:30p          1,990 f26ae6.t36
04/01/98  06:57a          1,865 f26ae6.t37
12/09/98  03:45p        160,936 ptrk.expval
04/04/98  11:44p            186 sz_convolute2.dat
             51 File(s)  28,017,506 bytes

 Directory of G:\f26be4

02/23/99  08:21a    <DIR>          .
02/23/99  08:21a    <DIR>          ..
12/30/98  02:56p            787 baserun1.dat
12/30/98  03:05p          3,095 DOSE.DAT
12/23/98  02:03p        498,181 F26BE4.BAK
12/30/98  03:03p         88,192 F26BE4.BPF
12/30/98  03:03p         12,008 F26BE4.bsr
12/30/98  02:56p        583,384 F26BE4.BTF
12/30/98  03:03p      2,658,707 F26BE4.btr
12/30/98  03:03p          2,672 f26be4.out
12/30/98  02:56p        498,181 F26BE4.RP
04/04/98  11:43p         11,979 f26be4.t01
12/23/98  01:55p         17,504 f26be4.t02
04/04/98  11:44p         11,964 f26be4.t03
04/04/98  11:44p         12,266 f26be4.t04
12/23/98  01:55p         17,392 f26be4.t05
04/04/98  11:44p         11,715 f26be4.t06
03/28/98  07:25a          6,070 f26be4.t07
03/27/98  09:33a          6,002 f26be4.t08
03/28/98  07:30a          6,002 f26be4.t09
03/27/98  09:33a          6,002 f26be4.t10
03/27/98  09:34a          6,070 f26be4.t11
03/27/98  09:34a          6,070 f26be4.t12
03/27/98  09:35a          6,070 f26be4.t13
03/27/98  09:35a          6,070 f26be4.t14
03/27/98  09:35a          6,070 f26be4.t15
03/27/98  08:27a          6,070 f26be4.t16
03/27/98  08:27a          6,002 f26be4.t17
03/27/98  08:28a          6,002 f26be4.t18
03/27/98  08:34a          6,002 f26be4.t19
12/14/98  12:21p          6,311 f26be4.t20
```

```
03/27/98  08:35a        6,002 f26be4.t21
03/27/98  08:36a        6,070 f26be4.t22
03/27/98  08:41a        6,070 f26be4.t23
03/27/98  08:41a        6,070 f26be4.t24
03/27/98  09:41a        6,002 f26be4.t25
03/27/98  09:41a        6,070 f26be4.t26
03/27/98  09:41a          698 f26be4.t27
03/27/98  09:41a        6,002 f26be4.t28
03/27/98  09:42a        6,002 f26be4.t29
03/27/98  09:42a        6,070 f26be4.t30
03/27/98  09:42a        6,070 f26be4.t31
03/27/98  09:43a        6,070 f26be4.t32
03/27/98  09:43a        6,070 f26be4.t33
03/30/98  02:38p        2,874 f26be4.t34
12/14/98  12:21p        2,911 f26be4.t35
03/30/98  02:30p        1,990 f26be4.t36
04/01/98  06:57a        1,865 f26be4.t37
12/30/98  02:56p      160,935 ptrk.expval
12/30/98  02:56p          185 sz_convolute2.dat
        50 File(s)  4,756,866 bytes

Directory of G:\f26be6

02/23/99  08:21a    <DIR>          .
02/23/99  08:21a    <DIR>          ..
04/04/98  11:19p          788 baserun1.dat
12/30/98  02:44p       28,295 DOSE.DAT
10/27/92  05:00a        5,527 EGAVGA.BGI
12/23/98  01:56p      498,181 F26BE6.BAK
12/23/98  04:35p       88,192 F26BE6.BPF
12/23/98  04:35p       12,008 F26BE6.bsr
12/23/98  02:03p      585,184 F26BE6.BTF
12/23/98  04:35p   25,695,107 F26BE6.btr
12/23/98  04:35p      206,921 f26be6.out
12/23/98  02:03p      498,181 F26BE6.RP
04/04/98  11:43p       11,979 f26be6.t01
12/23/98  01:55p       17,504 f26be6.t02
04/04/98  11:44p       11,964 f26be6.t03
04/04/98  11:44p       12,266 f26be6.t04
12/23/98  01:55p       17,392 f26be6.t05
04/04/98  11:44p       11,715 f26be6.t06
03/28/98  07:25a        6,070 f26be6.t07
03/27/98  09:33a        6,002 f26be6.t08
03/28/98  07:30a        6,002 f26be6.t09
03/27/98  09:33a        6,002 f26be6.t10
03/27/98  09:34a        6,070 f26be6.t11
03/27/98  09:34a        6,070 f26be6.t12
03/27/98  09:35a        6,070 f26be6.t13
03/27/98  09:35a        6,070 f26be6.t14
03/27/98  09:35a        6,070 f26be6.t15
03/27/98  08:27a        6,070 f26be6.t16
```

```
03/27/98  08:27a          6,002 f26be6.t17
03/27/98  08:28a          6,002 f26be6.t18
03/27/98  08:34a          6,002 f26be6.t19
12/14/98  12:21p          6,311 f26be6.t20
03/27/98  08:35a          6,002 f26be6.t21
03/27/98  08:36a          6,070 f26be6.t22
03/27/98  08:41a          6,070 f26be6.t23
03/27/98  08:41a          6,070 f26be6.t24
03/27/98  09:41a          6,002 f26be6.t25
03/27/98  09:41a          6,070 f26be6.t26
03/27/98  09:41a            698 f26be6.t27
03/27/98  09:41a          6,002 f26be6.t28
03/27/98  09:42a          6,002 f26be6.t29
03/27/98  09:42a          6,070 f26be6.t30
03/27/98  09:42a          6,070 f26be6.t31
03/27/98  09:43a          6,070 f26be6.t32
03/27/98  09:43a          6,070 f26be6.t33
03/30/98  02:38p          2,874 f26be6.t34
12/14/98  12:21p          2,911 f26be6.t35
03/30/98  02:30p          1,990 f26be6.t36
04/01/98  06:57a          1,865 f26be6.t37
12/09/98  03:45p        160,936 ptrk.expval
04/04/98  11:44p            186 sz_convolute2.dat
             51 File(s)  28,030,045 bytes
```

Attachment II

Result Figures

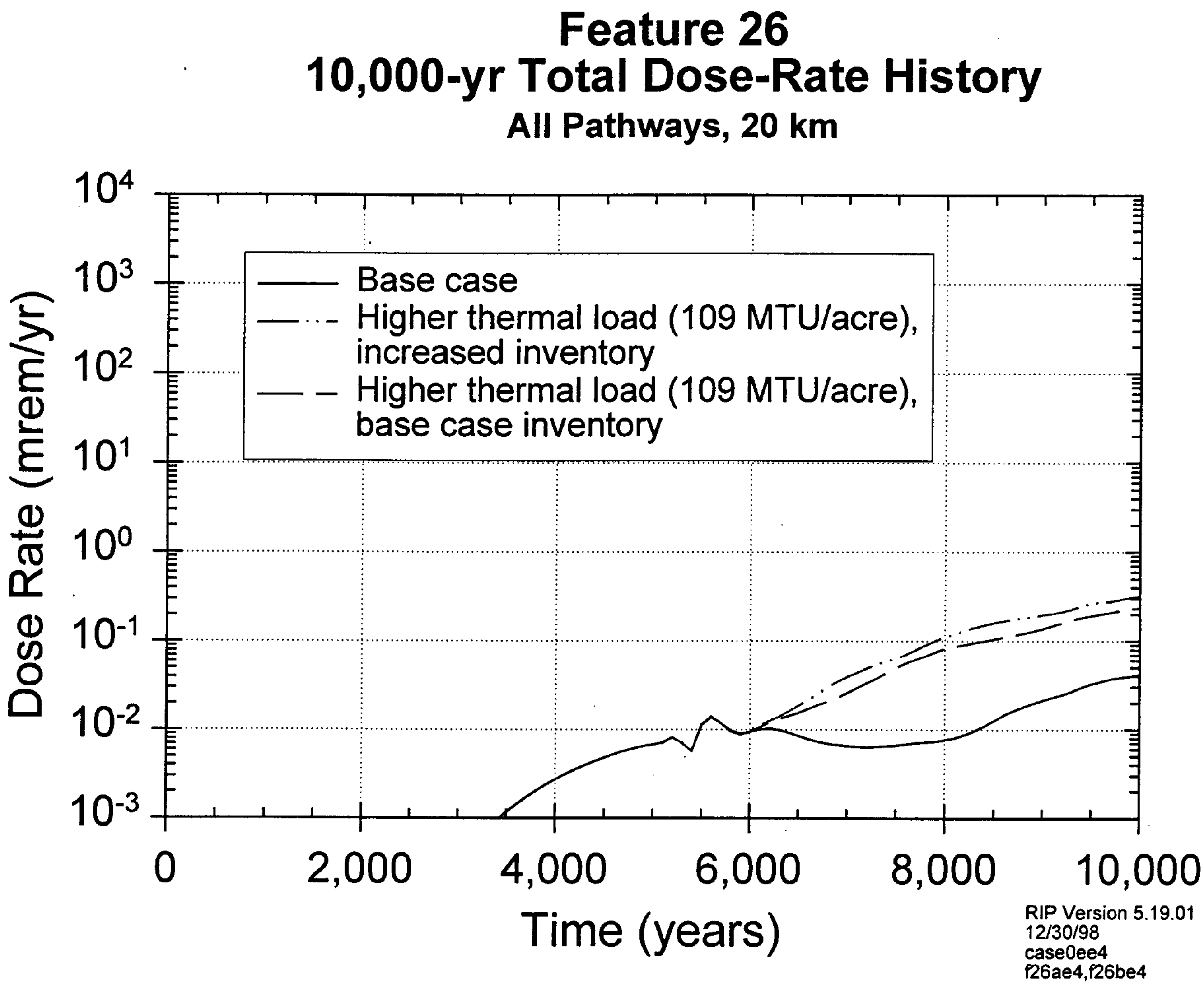

Figure 1. Base Case And Higher Thermal Load (F26) 10,000-Year Dose Rate Results.

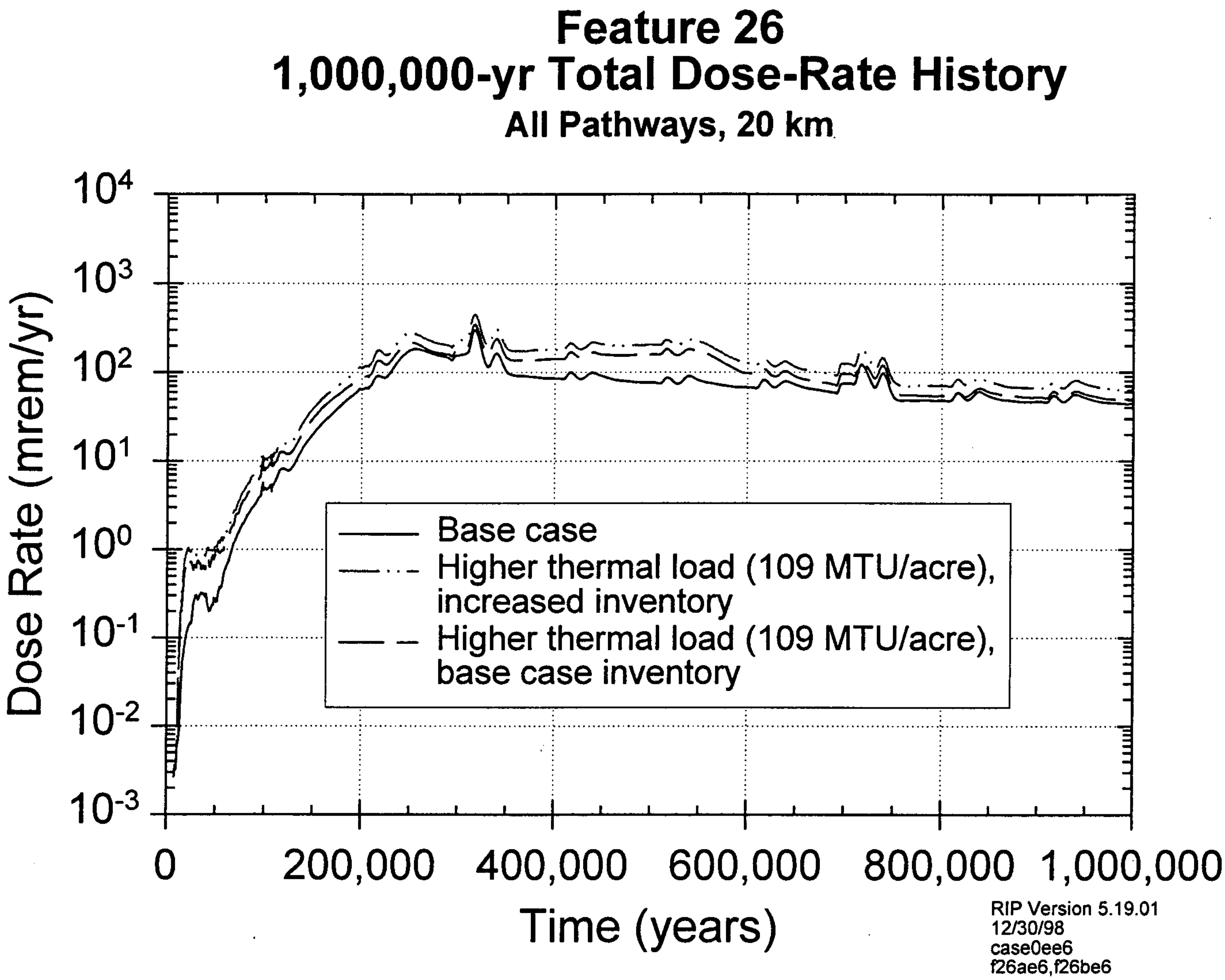

Figure 2. Base Case And Higher Thermal Load (F26) 1,000,000-Year Dose Rate Results.